

Amendments to the Claims

The following listing of claims will replace all prior versions and/or listing of claims in the application.

Listing of Claims:

1-2038. (cancelled)

2039. (currently amended): A method of treating a coal formation in situ, comprising:
providing heat from heaters positioned in heater wells to at least a ~~portion~~ section of the formation;
allowing the heat to transfer from the heaters to a part of the formation;
wherein superposition of heat from at least two of the heaters pyrolyzes some hydrocarbons in the part of the formation;
wherein the part of the formation has been selected for heating using a moisture content in the part of the formation, and wherein at least a portion of the part of the formation comprises a moisture content of less than about 15%; and
producing a mixture from the formation.

2040. (cancelled)

2041. (previously presented): The method of claim 2039, further comprising maintaining a temperature in the part of the formation in a pyrolysis temperature range.

2042. (previously presented): The method of claim 2039, wherein at least one of the heaters comprises an electrical heater.

2043. (cancelled)

2044. (previously presented): The method of claim 2039, wherein at least one of the heaters comprises a flameless distributed combustor.

2045. (previously presented): The method of claim 2039, wherein at least one of the heaters comprises a natural distributed combustor.

2046. (previously presented): The method of claim 2039, further comprising controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2047. (previously presented): The method of claim 2039, further comprising controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day during pyrolysis.

2048. (currently amended): The method of claim 2039, wherein providing heat from the heaters to at least the ~~portion~~ section of the coal formation comprises:

heating a selected volume (V) of the coal formation from the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is an average formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

2049. (original): The method of claim 2039, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

2050. (previously presented): The method of claim 2039, wherein allowing the heat to transfer to the part of the formation heats the part of the formation to increase a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

2051. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2052. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2053. (original): The method of claim 2039, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2054. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2055. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2056. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2057. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2058. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2059. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2060. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2061. (original): The method of claim 2039, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

2062. (previously presented): The method of claim 2039, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

2063. (original): The method of claim 2039, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2064. (original): The method of claim 2039, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2065. (previously presented): The method of claim 2039, further comprising controlling a pressure in at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2066. (previously presented): The method of claim 2039, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

2067. (previously presented): The method of claim 2066, wherein the partial pressure of H₂ in the mixture is determined at conditions of a production well.

2068. (previously presented): The method of claim 2039, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2069. (previously presented): The method of claim 2039, further comprising recirculating a portion of hydrogen from the mixture into the formation.

2070. (previously presented): The method of claim 2039, further comprising:
providing hydrogen (H₂) to the heated part of the formation to hydrogenate hydrocarbons in the part of the formation; and
heating a portion of the part of the formation with heat from hydrogenation.

2071. (original): The method of claim 2039, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

2072. (previously presented): The method of claim 2039, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

2073. (previously presented): The method of claim 2039, wherein allowing the heat to transfer increases a permeability of at least a majority of the part of the formation such that the permeability of the majority of the part is substantially uniform.

2074. (original): The method of claim 2039, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by Fischer Assay.

2075. (previously presented): The method of claim 2039, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

2076. (previously presented): The method of claim 2039, wherein three or more of the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

2077. (previously presented): The method of claim 2039, wherein three or more of the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2078. (previously presented): A method of treating a coal formation in situ, comprising:
providing heat from heaters positioned in heater wells to a part of the formation;
allowing the heat to transfer from the heaters to the part of the formation;
wherein superposition of heat from at least two of the heaters pyrolyzes some hydrocarbons in the part of the formation;

wherein at least a portion of the part of the formation has an initial moisture content of less than about 15%; and
producing a mixture from the formation.

2079. (cancelled)

2080. (previously presented): The method of claim 2078, further comprising maintaining a temperature in the part of the formation in a pyrolysis temperature range.

2081. (previously presented): The method of claim 2078, wherein at least one of the heaters comprises an electrical heater.

2082. (cancelled)

2083. (previously presented): The method of claim 2078, wherein at least one of the heaters comprises a flameless distributed combustor.

2084. (previously presented): The method of claim 2078, wherein at least one of the heaters comprises a natural distributed combustor.

2085. (previously presented): The method of claim 2078, further comprising controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2086. (previously presented): The method of claim 2078, further comprising controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day during pyrolysis.

2087. (currently amended): The method of claim 2078, wherein providing heat from the heaters to ~~at least the portion~~ part of the coal formation comprises:

heating a selected volume (V) of the coal formation from the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (P_{wr}) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is an average formation bulk density, and wherein the heating rate (h) of the selected volume is about 10 °C/day.

2088. (original): The method of claim 2078, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

2089. (currently amended): The method of claim 2078, wherein allowing the heat to transfer to the part of the formation heats the part of the formation to increase a thermal conductivity of at least ~~a portion~~ some of the part of the formation to greater than about 0.5 W/(m °C).

2090. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2091. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2092. (original): The method of claim 2078, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2093. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2094. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2095. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2096. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2097. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2098. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2099. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2100. (original): The method of claim 2078, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

2101. (previously presented): The method of claim 2078, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

2102. (original): The method of claim 2078, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2103. (original): The method of claim 2078, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2104. (previously presented): The method of claim 2078, further comprising controlling a pressure within at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2105. (previously presented): The method of claim 2078, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

2106. (previously presented): The method of claim 2105, wherein the partial pressure of H₂ in the mixture is determined at conditions of a production well.

2107. (previously presented): The method of claim 2078, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2108. (previously presented): The method of claim 2078, further comprising recirculating a portion of hydrogen from the mixture into the formation.

2109. (currently amended): The method of claim 2078, further comprising:
providing hydrogen (H₂) to the heated part of the formation to hydrogenate hydrocarbons in the part of the formation; and
heating ~~a portion~~ at least some of the part of the formation with heat from hydrogenation.

2110. (original): The method of claim 2078, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

2111. (previously presented): The method of claim 2078, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

2112. (previously presented): The method of claim 2078, wherein allowing the heat to transfer increases a permeability of at least a majority of the part of the formation such that the permeability of the majority of the part is substantially uniform.

2113. (original): The method of claim 2078, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by Fischer Assay.

2114. (previously presented): The method of claim 2078, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

2115. (previously presented): The method of claim 2078, wherein three or more of the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

2116. (previously presented): The method of claim 2078, wherein three or more of the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2117 – 5149. (cancelled)

5150. (currently amended): A method of treating a coal formation in situ, comprising:

evaluating a moisture content of coal in the coal formation to identify a portion of the coal with a moisture content that is less than about 20%;

providing heat from heaters positioned in heater wells to the portion to heat the portion so that an average temperature in the portion is above a temperature sufficient to pyrolyze coal in the portion;

wherein superposition of heat from at least two of the heaters pyrolyzes some hydrocarbons in the ~~part~~portion of the formation; and

producing a mixture from the coal formation.

5151. (previously presented): The method of claim 5150, further comprising controlling a pressure and a temperature in at least a majority of the portion, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

5152. (currently amended): The method of claim 5150, wherein providing heat from the heaters to the portion comprises providing heat to a portion of the coal identified as having a moisture content that is less than about 15%.

5153. (previously presented): The method of claim 5150, wherein providing heat from the heaters to the portion comprises providing heat to a portion of the coal identified as having a moisture content that is less than about 10%.

5154. (previously presented): The method of claim 5150, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

5155. (currently amended): The method of claim 5150, wherein providing heat from the heaters to ~~at least~~ the portion of the coal formation comprises:

heating a selected volume (V) of the coal formation from the heaters, wherein the coal formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some coal in the selected volume of the coal formation; and

wherein heating energy/day (P_{wr}) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is an average formation bulk density, and wherein an average heating rate (h) of the selected volume is less than about 10 °C/day.

5156. (currently amended): The method of claim 5150, wherein the mixture comprises H₂, and further comprising the step of introducing a portion of the hydrogen into the coal formation.

5157. (currently amended): The method of claim 5150, wherein the mixture comprises H₂ and condensable hydrocarbons, and further comprising the step of hydrogenating condensable hydrocarbons of the mixture with H₂ from the mixture.

5158. (currently amended): The method of claim 2039, further comprising providing H₂ to at least ~~a portion~~some of the formation.

5159. (currently amended): The method of claim 2078, further comprising providing H₂ to at least ~~a portion~~some of the formation.